ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

Project 531

June 2002

DEVELOPMENT OF A PLAN FOR COMPLIANCE WITH NCHRP 350 FOR TEMPORARY CONCRETE BARRIERS

Background - NCHRP 350

The Federal Highway Administration (FHWA) mandated on July 27, 1997, that all roadside and work zone devices used on the National Highway System (NHS) be crash tested to National Cooperative Highway Research Project (NCHRP) Report 350 requirements. The FHWA categorized these devices into four categories, each having its own testing requirements and implementation date.

The differences in testing of the categories depend on the type of device and the severity of velocity change from a possible vehicular impact with the device. Additionally there are three levels of the NCHRP 350 test. Each level is designed for a higher speed test impact. Four categories are defined in Report 350:

Category I includes small and lightweight items, such as channelizing and delineating devices. Examples of Category I devices are cones and tubular markers. A self-certification is adequate for NCHRP 350 compliance for devices in this category.

Category II includes barricades, portable sign supports, vertical panels or cones with lights, and plastic drums. Category II devices qualify for reduced testing requirements.

Category III includes devices that might cause a significant velocity change upon vehicular impact. Devices classified in this category, such as barriers, crash attenuators, and fixed sign supports, are to be tested to the full requirements of NCHRP 350.

Category IV includes arrow displays or other trailer mounted devices, portable variable message signs, and portable traffic signals. These devices are not to be used unless tested to show that they are crashworthy, unless they are shielded or installed outside the clear zone.

FHWA Requirements

FHWA requires that by October 1, 2002, all Temporary Concrete Barriers (TCBs) used on the National Highway System to be compliant with NCHRP Report 350. The exception is TCB classified as AASHTO (American Association of State Highway Officials) design, made prior to October 1, 2000. Units built to the AASHTO TCB design can be used for the duration of their individual useful lives.

ADOT's Transportation Safety Goals:

The Arizona Department of Transportation strives to always provide a safe transportation environment. Its goal is to provide Arizona's motoring public and visitors with a quality and safe highway system. Safety and traffic control devices used by the Department are therefore examined and evaluated closely.

1. PROJECT SCOPE

To comply with the requirements, a research project panel was formed, representing involved sections of ADOT, the local traffic control industry, and FHWA. The panel determined that the most deliberate, expeditious, and cost effective method of approaching a solution was to review systems that had already been tested and approved as compliant TCB. Their goals were to:

1. Implement An Existing Approved System
The Jersey-shape system used by the Arizona Department of Transportation (ADOT) is not NCHRP 350 compliant, but has been accepted as an AASHTO design system.

2. Be Similar To ADOT's Present System
A TCB system similar to that currently used by ADOT was desirable, since it would save on the cost of re-manufacturing concrete forms.

3. Must Meet FHWA Compliance Criteria
The selected system must meet NCHRP Report 350 criteria, per the FHWA memorandum requiring compliance by October 1, 2002.

2. EVALUATION AND SELECTION

1. Evaluation Committee
ADOT first sought proposals from qualified researchers for an evaluation of its system, and other agencies' NCHRP 350-compliant designs which ADOT might adopt, in order to comply with the federal mandate by the 2002 deadline. No valid responses were received, however.

The project Technical Advisory Committee (TAC) and its Evaluation Panel (EP) agreed to investigate ADOT's options in-house, and to provide findings and recommendations to ADOT management for the adoption of a qualified and compliant TCB system.

The TAC / EP included members of ADOT's Traffic, Planning, Research, Roadway Design, Construction, Construction Quality Control, and District sections. It also included the American Traffic Safety Services Association (ATSSA), representing TCB manufacturers and traffic control contractors, and the FHWA.

2. Systems Review
Many states have tested their TCB systems, or modified versions of them, under NCHRP 350 criteria, and have obtained FHWA approval for their use on the National Highway System.

There are currently two common shapes of TCB: the Jersey shape and the F shape. The difference is the ground-up vertical dimension to the slope break point. The Jersey shape generally has a total of 13" for this dimension and the F shape generally has a total of 10".

3. Committee Evaluation
The TAC/EP decided that ADOT should adopt a non-proprietary TCB system. To address the issue of differentiating between compliant and non-compliant systems after the October 1, 2002 deadline, they also agreed that a drop-dead date for new TCB should be adopted.

The TAC/EP industry representative suggested a date extending five years beyond the adoption of a new system. This would allow the industry to recover its manufacturing cost of any system that was made up to that time.

Additionally, the TAC/EP agreed that systems to be reviewed should utilize a pin and loop connection. Systems without this connection, such as those using slots or hooks, were ruled out. Those systems are either proprietary, or require additional time and effort for installation and relocation. Wire loop designs were ruled out also. National experts in NCHRP-350 testing, including FHWA test reviewers, have stated that in their opinion, wire loop systems have a lesser chance of passing the crash test requirements.

2.4 Consultant Review
To review its evaluation, ADOT retained the Midwest Roadside Safety Facility (MwRSF) of the University of Nebraska, a research facility with some of the nation's foremost experts on NCHRP 350 crash testing.

The Evaluation Panel's work has withstood the scrutiny, and received the validation, of nationally-recognized crash testing experts. The ADOT Panel is therefore confident that it is providing the safest and best option to the citizens of Arizona.

3. EVALUATION

1. Systems Evaluated

Based on recommendations from national experts, the TAC / EP decided not to test the ADOT TCB system. Significant modifications to the Arizona TCB would be needed for NCHRP 350 crash testing, which would still not guarantee adequate performance in the test. These design modifications and tests would most likely span beyond the mandated compliance date. Therefore, due to these recommendations and time constraints, the TAC / EP decided that ADOT should adopt a system already approved by the FHWA for use on the National Highway System.

Few TCB systems have passed NCHRP 350 testing. Of those that have, there are at least three proprietary (privately owned) systems that require a payment to the owner in order to use that design. Non-proprietary systems, however, which ADOT can use without a royalty payment, have been tested and been approved for Iowa, Georgia, California, Nevada, Virginia, California, Oregon, Idaho, and Ohio (assumed Ohio approval at the time of this project). The California, Nevada and Virginia systems require design considerations. The California and Nevada versions are K-shape. The Virginia design is not a pin and loop connection system. Georgia's system is a somewhat modified Jersey-shape. Iowa's system uses a retaining bolt through the pin.

To effectively address the barrier shapes that are used in ADOT (F-shape in permanent installations and Jersey-shape for TCBs), the evaluation considered the Idaho, Ohio and Oregon designs. All three systems have non-proprietary designs, have passed NCHRP 350 testing, and utilize a pin and loop connection. The Oregon system is an F-shape system, and the Idaho and Ohio are Jersey-shape systems.

Idaho has tested its 20-foot section system, and won approval from the FHWA for use on the NHS. There is no Styrofoam pad requirement for the use of this system. Two connection mechanisms were tested: a bolt and a drop pin. The system can use a 25-inch long bolt and hex nut or a 26-inch long, 1.25-inch diameter rod that is not secured at the bottom.

Ohio has tested a 10-foot section of their Jersey shape, and (at this time) anticipated approval of a 12-foot section of the same design, based on the performance in that test. The two systems are similar except in segment length. The Ohio system uses a bolt connection and does not require a Styrofoam pad.

The third system is the Oregon F-shape design. The 12.5-foot long Oregon TCB system has been tested and approved in both 32-inch tall and 42-inch tall versions of the design. The taller barrier was tested to test levels 3 and 4 criteria with a bolt connection, to be used primarily in medians of all interstates and designated freight routes. The 32-inch (32" tall, 24" bottom width and 9.5" top width) design was tested to level 3 criteria with a pin connection. The approval letter issued by the FHWA stated that both barriers exhibited the least amount of deflection and resulted in the most stable post impact vehicle trajectories of any free-standing precast barrier tested to date.

2. Evaluation Criteria

ADOT's TAC / EP developed an evaluation matrix to assist in ranking the systems under consideration. The Panel evaluated the systems and scored each category on ease of fabrication and installation, crash test performance, cost, size options, and ease of field inspection.

Arizona's TCB manufacturers and contractors, via the ATSSA representative, provided industry's ranking, evaluation and comparison data for several of the matrix categories, such as ease of installation, cost and fabrication.

Based on this evaluation, the TAC / EP ranked the Oregon F shape system as the most suitable design for ADOT use. The Oregon system performed best in crash testing and is equal or superior to the other systems evaluated.

The Idaho TCB system also rated well in this evaluation, but it is limited to a 20' section, and such long sections pose difficulty in certain installations, such as on curves.

The Panel unanimously recommended that ADOT adopt an F-shape barrier. In NCHRP 350 crash testing, the F-shape barrier has demonstrated a superior performance to that of

Jersey-shape barrier. This advantage has been stated in several crash-test reports and in a paper by FHWA's Charles McDevitt entitled "Basics of Concrete Barriers." He states that based on research and testing, *"A parametric study (systematically varying the parameters) of various profile configurations that were labeled A through F showed that F performed distinctly better than the NJ-shape. The results of these computer simulations were confirmed by a series of full-scale crash tests. Configuration F became known as the F-shape."*

4. RECOMMENDATIONS

The Technical Advisory Committee Evaluation Panel recommendations are as follows:

1. System
The TAC / EP recommends that ADOT adopt the non-proprietary, NCHRP 350 Test Level 3 approved, 12.5-foot long, 32-inch high Oregon TCB design as an ADOT TCB design. ADOT has already obtained approval from the FHWA for the manufacture of 20-foot sections of the Oregon TCB design.

2. Implementation Date
The TAC / EP recommends that a drop-dead date of 5 years from the date of adoption be established for the use of the current TCB system. If the new system is adopted by ADOT on January 1, 2002, then barriers using the current design that were manufactured before October 2000, can be used for up to 5 years from that adoption date, based on their condition. That is, by January 1, 2007, all TCBs installed on ADOT projects shall be of the new design, with no exceptions.

This approach was part of ADOT's agreement with FHWA for the October 2000 AASHTO TCB design acceptance. This drop-dead date was established in cooperation with FHWA, the industry, and concerned ADOT sections.

4.3 Incentive
The Panel discussed recommending incentive pay to TCB contractors to expedite the implementation of the new design. After considering the consultant review and panel discussion, it was agreed that, although it is a desirable approach, it might be best if recommended by the industry or by ADOT Construction Group directly to management.

4.4 Consultant Review
The Midwest Roadside Safety Facility review of the TAC / EP summary report agreed with the findings, but with two recommendations. The first was to add a fracture-resistant steel specification, to require steel that will not fracture in regions with temperatures of freezing or below. The second point was to not recommend incentive pay since there is no cost saving from an accelerated implementation.

5. IMPLEMENTATION

1. Plan
The Oregon TCB system was selected by the Panel for adoption by ADOT. The Oregon standard drawings have been converted into ADOT standard drawings, with notations specifying fracture-resistant steel, and with implementation dates. These drawings will be signed and approved for distribution by affected group managers, thus becoming the new ADOT standard. On these drawings, the implementation date will serve as a reminder and support to contract documents that outline the drop-dead date requirements for TCBs.

2. Approvals
The adopted system and implementation dates, including the five-year span from date of adoption for use of ADOT's AASHTO design TCBs, have been reviewed with ADOT management and have been accepted.

3. Industry Partnering
Industry representatives stated at a partnering meeting that they will most likely begin manufacturing the new design as soon as they receive signed copies of the standard drawings. These drawings will serve as notification to ADOT designers, consultants and contractors of the adoption of the new system.

Note: The full report on this project, Development of a Plan for Compliance With NCHRP 350 for Temporary Concrete Barriers, by Muhannad Zubi and Annette Riley (Report FHWA-AZ-02-531, June 2002) may be obtained from ATRC at 206 S. 17th Ave. MD 075R, Phoenix, AZ 85007. Copies are also on the ATRC web page.